Mystical bird

AN AUSTRALIAN COMPANY HAS DEVELOPED AN UNMANNED AIRCRAFT FOR COMMERCIAL USE WITH LATEST-TECHNOLOGY CAMERA EQUIPMENT AND ENGINE

BY PETER HILL

The Warrigal is a small, lightweight unmanned aircraft, weighing 4.3kg, with a 1.5m wingspan, and stretching a mere 1.1m in length. It has been developed by Australian firm V-TOL Aerospace. 'Warrigal' is a local aboriginal term meaning mystical bird, and it is the foundation technology for the company's Earth observation program.

Unmanned aircraft technology is not new and has been in the inventory of many military forces worldwide for some decades. A period of discovery is leading to much interest in adopting this technology for applications in the commercial sector. V-TOL Aerospace started off with the idea of using larger unmanned aircraft, but the company saw that this class of unmanned craft will have a much longer market acceptance and regulatory phase before commercial services could be realized. A strategic business decision was made three years ago to look at smaller and lighter unmanned aircraft. The right technology mix has now been developed to reach the target of establishing a pilot program to demonstrate the Earth observation concept by the middle of 2010.

"Earth observation is essentially an integrated sensor network with unmanned aircraft enabling collected data to be received in real time over a web-based user interface. Since then, the company has focused on developing a systems-and-solutions approach over a simple platform approach," explains ????xxxx.

Warrigal history

The goal of the project was to design and construct a wide-envelope unmanned aircraft that can fly at relatively high and low speeds on the same mission. It needed to be highly durable and reliable to obtain airworthiness status to operate over a populated area – the holy grail for unmanned aircraft. Additionally, it was required to operate day or night, in high wind and light rain with an endurance of 1.5 hours.

The work began on the whiteboard with a design concept and many hours on the computer. With a combination of hand calculations and MATLAB programs, a design that satisfied the design objectives was eventually found. The aircraft configuration, body shape, and airfoil selection were the first aspects of the aircraft that were designed. Aircraft data for many existing aircraft was taken from the internet and compiled into a spreadsheet to look for trends in different characteristics, such as thrust-to-weight, aspect ratio, and airfoil.

During the initial design stages, the engineering team built two prototypes and worked on two different aspects. Alpha team worked on impact design, and Bravo team worked on reliability and safety. A third team would later work on software integration of the flight computer and navigation system. In addition, members from the engineering team supervised a work-experience project using local students to build a simple wind tunnel model developed in-house, using a ducted fan, a sheet metal box, and a clear plexiglas tunnel. This wind tunnel model would be used later for various tests.

By the fourth design iteration and with over 100 flight-test hours performed in trim flights, standard flight profiles, and extreme flight profiles, engineers were happy with the data and the final outer shape. In parallel to Alpha team's efforts with the flight experiments out at the company's flight test range, Bravo was conducting exhaustive reliability tests in the wind tunnel on all control surfaces and various types of servos to determine suitable reliability goals.

In addition, considerable effort was spent on understanding and determining a suitable powerplant for the aircraft. Exhaustive tests were undertaken using a wide range of internal combustion and electric engines, resulting in a Hyperion electric engine proving to have superior performance capabilities over internal combustion engines. Tests showed the electric engines were more reliable than the combustion engines. Electric engines also have fewer working parts, are quieter, and are able to be re-started in-flight. This was a major factor in the selection process.

During the engine test flights, the flight team experienced the internal combustion engines shutting down on a number of occasions, and the test aircraft had to be recovered back to the field. If it had not been for the skill of the remote control (RC) pilots in gliding the remote control aircraft back to the field, the damage would have been a lot worse.

It was decided that the logical choice was to have electric engines powered by batteries. Battery technology is increasing at a fast rate, and electric engines offer future growth with other emerging technologies in fuel cells and solar electric.

Pilot station

The pilot station, or ground control station as it is referred to at times, is the pilot interface on the ground that manages all communication between the ground and flight electronics. The pilot station resembles that of a normal personal aircraft, and the virtual cockpit has readouts that include heading, airspeed, altitude (pressure, as well as physical), climb rate, ground speed, angle of attack, pitch, yaw, and an artificial horizon. The team wanted the control interface to be user-friendly for wider uptake and acceptance. Research found that if the team were to succeed in obtaining airworthiness approval to operate over a populated area, it was important for the pilot station to reflect what current pilots and regulators are used to and feel comfortable with.

Gavin Broadbent part of the flight test team checking test equipment at the mobile ground control station

"Battery technology is increasing at a very fast rate and electric engines offer future growth"

To do this, the pilot station needed a distinct flight simulator feel and look. The main control input is a joystick, but the pilot has the option of 'click and fly' through the use of the mouse on the computer. The pilot monitors two visual screens: the first screen is a moving map display that tracks the unmanned aircraft over a Google earth-terrain image; and the second is the live digital feed from the onboard camera that gives the operator the pilot's view.

Power supply

The current power supply for the aircraft is a four-cell lithium polymer matrix 21004S battery. The battery is capable of running all the avionics and providing power to the electric engine for 1.5 hours. During the majority of test missions flown, the flights were limited to one-hour sorties. The company is working in partnership with a local university on fuel cell and renewable energy power supply technologies for future longer duration flights.

The RF modems are MaxStream long-range communication modems with their own communication protocol. They operate at a frequency of 900MHz and are frequency hopping spread spectrum modems. One drawback of using the ISM bands is that testers found them to be heavily dependent on line-of-sight (LOS) operations between the transmitter and receiver. This problem has been remedied for the Earth observation program by trialing the use of, and establishing, a small network of ground-based broadcast antennas at various locations. This concept can be easily rolled-out on a larger scale in an urban environment once final system approval has been achieved.

In addition, the team has been working on a tracking antenna that will be fitted to a 4.57m (15ft) telescopic mast. Initial tests completed have shown favorable results with an increased range of 80% over the standard LOS 6km range. The major limiting factor for the communication issues has been the company's ability to operate above 121.9m (400ft) AGL in the National Airspace System. Other options for long-range communication is the use of a satellite system with packets of information stream instead of the real-time live streaming. This option is much more expensive, but is an option for clients in remote central Australia.

Camera payload

The Warrigal and its various subsystems was designed from the outset to support a wide

range of camera options. In previous unmanned aircraft programs, the team witnessed a tendency to focus just on the platform, and the camera system was often the last element and in most cases considered an afterthought. It was the team's opinion that the camera and payload module is the single most important element in the service-delivery aspect of unmanned aircraft, and therefore should be of high importance in any unmanned aircraft project.

Internal market research highlighted the fact that the end-user did not think too much about how the data was collected, but simply wanted a solution delivered on time and on budget. Hence, considerable time and effort was spent on payload development. With smaller unmanned aircraft, everything is a compromise. The engineers constantly battle with weight, endurance, capability, safety, and reliability. In saying this, there has been a remarkable amount of advancement made in miniaturization of computers, GPS, and cameras.

"The company is in low-scale initial production of three aircraft for the Earth observation program"

Various technology partners provided assistance with the Warrigal major camera and data platform. It is fitted with an onboard vision processing unit (VPU), enabling computer vision and inertial measurement for solid video. It is an amazing and exciting development, together with the addition of small megapixel cameras. Three years ago when the project was first started, the small camera was pretty limited at around 480 TV lines and picture quality was low. Now, the team is able to utilize HD megapixel cameras of the same type and quality found in most mobile phones to a quality of 3-5 megapixels.

Currently, the company is preparing one of the Warrigal unmanned aircraft to test two new camera systems. One is a 16-megapixel camera, and the second is a camera array that has four cameras positioned to allow 180° high-definition snapshot images on the fly. This means the system can take a single picture of an entire valley and add value with third-party spatial layers, or pull vast amounts of information from a single picture, such as weeds, vegetation, livestock, fences, and roads.

The goal was to design, develop, and build a small unmanned aircraft (<5kg) that has a wide flight and capability envelope maximizing advancements in electronics, cameras, and small-engine technology. It needed to be cost-effective and able to meet the requirements of a growing civil and commercial market for rapid and accurate airborne information.

The Warrigal unmanned aircraft was officially launched on November 25, 2009 in Ipswich, Queensland, Australia, with over 300 flight hours flown since the project commenced in 2007. The company is in low-scale initial production of three aircraft for the Earth observation program. A total of eight Warrigal unmanned aircraft have been produced, and this number is expected to grow substantially. Although the project is small-scale compared to those conducted by the larger manned aircraft manufacturers, it still presented engineering challenges and required the skills of aeronautical engineers, experienced small-aircraft manufacturers, avionic specialists and subject-matter experts – a team effort requiring many disciplines and skill sets. Unmanned aircraft are proving themselves to be invaluable in a variety of applications and are a useful tool to supplement the manned aerospace industry in the future. ∎

Conducting a post flight analysis of a smaller Warrigal back in the lab

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